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## *ANNUAL MEETING H. S. P. A.*

The annual meeting of the Hawaiian Sugar Planters' Association will be held November 16, 17, 18 and 19. It is expected that the reports of Committees will be printed and distributed before the meeting; this should enable members to thoroughly digest the reports and be prepared to discuss the matters therein referred to. By this means the objects and purposes of the meeting will be more nearly carried out than heretofore, and much benefit should be derived from the discussion.

For some years it has been the custom to call the meetings for Monday and Tuesday in order to enable the Managers to return to their homes by the Tuesday steamers; but plantation business usually required a considerable portion of their time and the meetings suffered in consequence; this year it has been decided to extend the meetings over a number of days beginning with Wednesday, and to adjourn each day early enough to enable the members to transact their other business.

## *INOCULATING THE SOIL.*

In the Century Magazine for October there appears an account of the discovery of a method of inoculating the soil with bacteria which absorb from the air and impart to the plant and surrounding soil a supply of nitrogen.

The substance of the article is as follows: The beginning of investigation which resulted in the discovery dates back some years when a German scientist found that leguminous plants obtain their nitrogen from the air and not from the nitrates in the ground, and that such plants leave the soil in better condition than before. The nodules or tubercles found on the roots of clover and upon other plants of a similar character were determined to be not disease spots or wounds, as had been supposed, but living bacteria, and the larger the nodule the more healthy and vigorous the plant; and that these bacteria are constantly, during the life of the plant, absorbing notrogen from the air and imparting it to the soil and plant.

It occurred to a German professor—Nobbe—that if these bacteria could be bred and distributed into the ground legumes would grow in barren soil, and that by giving the soil the nitrogen which it lacked, a rotation of crops would be feasible. He proceeded to breed colonies of the germs and formed a company for putting them on the market under the name of *nitragin.* This was widely advertised and his bottles of nitragin had a large sale for a time, but the promised miracles did not materialize, and the experiment was for a time being dropped.

It fell to the lot of Doctor George T. Moore of the United States Department of Agriculture, to carry on the experiment to a successful and practical finish. Following along the lines of research of Professor Nobbe he ascertained that Noble's bacteria were so highly bred and overfed that they became weakened and when turned out to hustle for themselves invariably perished. Dr. Moore fed his bacteria with little more than enough to keep their appetites sharpened and to stimulate their desire to obtain more nitrogen. By continuing this be developed a hardy, vigorous bacteria, which when turned into the ground prospered and the nodules which they formed grew to large size.

"Having secured a type of bacteria, the nitrogen fixing power of which was permanent, the next step was to obtain a simple means of distributing them to the persons who desire to inoculate their land. Experiments showed that bacteria when grown upon nitrogen—free media will retain their high activity for a long time if carefully dried out and revived in a liquid medium. Dr. Moore also discovered that by using some absorbent like cotton, a small piece of which will soak up millions of the organisms, and then by allowing these cultures to become dry, the bacteria can be sent to any part of the world and yet arrive in perfect condition."

The discovery was patented by Doctor Moore and by him deeded to the Department of Agriculture of the United States in trust for the American people, and for some months past the Department of Agriculture has been mailing to farmers desiring to inoculate their land material sufficient for several acres, put up in three packages with full directions for the breeding and feeding of the germs and the inoculation of the soil or of the seeds to be planted.

The results have been most surprising and satisfactory. Statistics have been carefully kept and numerous instances are shown where inoculated seed has been sown in poor or barren soil and crops have been obtained which far exceed those grown upon the best and most fertile land. The article is replete with cuts showing comparisons of the results obtained from inoculated and uninoculated seed.

Carrying the experiments further it is shown that cotton, wheat, rye, oats, etc., planted after inoculated crops of legumes or clover give increased yields varying from forty to 400 per cent. of the former original yield. A table showing these results is very interesting and is as follows:

| | Original yield per acre. | Yield per acre after inoculated crop. | Grain in weight. | Grain in value. | Per cent. of gain. |
|---|---|---|---|---|---|
| | | After red clover | | | |
| Cotton ........ | 932 lbs. | 1304 lbs. | 372 lbs. | $44.64 | 40. |
| | | After crimson clover | | | |
| Potatoes ...... | 67.8 bush. | 102.2 bush. | 34.4 bush. | 15. | 50 |
| | | After velvet beans | | | |
| Oats .......... | 8.4 " | 33.6 bush. | 25.2 " | 9 | 300 |
| | | After melilotus | | | |
| Wheat ......... | 18.6 " | 26.9 bush. | 8.3 " | 6.50 | 46 |
| | | After peas | | | |
| Rye ........... | 4.5 " | 23.5 bush. | 19. " | 9.85 | 400. |

The germs it is said may be used in any climate but only in connection with leguminous plants. Of course where the soil is rich in nitrates the yield may not be appreciably increased, but in barren or worn out soils the results are truly astonishing.

The renewal of the soil by this extremely simple method is a matter of the utmost importance to all agricultural industries and should be of the greatest interest to the planters of Hawaii. The system here in vogue growing out of special conditions, of taking everything from the soil and replacing nothing, except chemical fertilizers, cannot be expected to satisfy nature for all time to come. On the vast majority of the sugar estates but little of the waste products is returned to the soil to replace what the crop has taken therefrom. The cane tops are utilized for planting and cattle feed and the trash remaining on the fields is necessarily burned to destroy the injurious insects; in but few instances is attention given to the conservation and proper application of stable manure to the fields. The bagasse is almost entirely used as fuel and furthermore its application to the soil would be of doubtful value unless applied to lands which are resting. At the present time the mud-press cake is the only waste product universally returned to the soil.

To obtain successive crops from the same lands almost entire reliance is placed upon chemical fertilizers applied in large quantities. It is true that this allows the planter to crop his land more often than if he allowed it to lie fallow or better still, planted a leguminous crop and plowed it under. But the time has arrived on some plantations and will inevitably come to others where the chemical fertilizer will no longer answer the purpose and the soil will fail to respond.

The original virgin soil may endure this successive cropping for many years during which with the aid of fertilizers it will yield profitable crops, but every plantation is not blessed with such soils, and where the soil is poor or shallow the evil results of continuous planting without resting the soil or the replacing therein a portion of that which nature has given, will show in a comparatively short period, notwithstanding the use of high grade fertilizers.

If an experiment such as is suggested in the article referred to could be conducted upon some of the plantations where they are compelled to rest a portion of the land each season, it would be interesting to watch the results, and if they should be on a par with the results shown in the foregoing table the experiment would be a decided success and somewhat revolutionize the present system of cultivation.

Intensive farming the world over has displaced the extensive system, because the farmer through the scientific knowledge which he has acquired is enabled at a less cost to make a small area produce as much or more than the large areas. So far as our local conditions are concerned it is for each planter to determine whether or not modern, scientific agricultural practices shall be tried and adopted. In many cases the Experiment Station and its sub-stations will determine whether certain methods are worthy of application and will lend advice and assistance in many instances; but on the whole it is almost entirely within the province of the planter himself to apply or reject scientific principles of the tilling of the land.

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## *INOCULATION OF SOILS.*

[Below we reproduce a hitherto unpublished paper by Ernest E. Hartmann. It represents a report on the deterioration of crops written in 1899, and is of particular interest today in view of the recent developments in soil-bacteriology.]

A few years ago my attention was drawn to several plats or pieces of land, on which the cane had a starved, sickly appearance. As first step on the way to become acquainted with the cause or causes of this phenomenon, the agricultural analysis of the soil suggested itself. Investigations carried out in this direction led to but half satisfactory results.* While the treatment those results pointed to (slaked lime) acted beneficially in some instances, it did not have any effect as far as visible at present, in some others; and the question as to the cause of the apparent strility in these cases was still left open.

When starting afresh on investigations on this subject, I decided to omit the analysis of the strong acid soil extracts for reasons given in the article above mentioned, and to restrict myself to the determination of the available portions, i. e. nutrients soluble in very dilute acids. The results are given below. Field A produces good average crops, B is a field in the vicinity showing deterioration most characteristically, C is a piece of new land bearing a heavy crop of young cane taken into an older field D, which promises but a scant crop. C and D are cultivated together, E and F have been taken from parts of the district, where deterioration has so far not shown itself.

| A | 1 | 2 | 3 | 4 | Average. |
|---|---|---|---|---|---|
| Potash | .009 | .019 | .014 | .007 | .012 |
| Phosphoric acid | .0032 | .0051 | .0030 | .0030 | .0036 |
| Lime | .180 | .106 | .224 | .166 | .169 |

| B | 1 | 2 | 3 | 4 | Average. |
|---|---|---|---|---|---|
| Potash | .016 | .018 | .012 | .012 | .014 |
| Phosphoric acid | .0040 | .0042 | .0031 | .0045 | .0039 |
| Lime | .157 | .160 | .130 | .062 | .127 |

| C | 1 | 2 | 3 | Average. |
|---|---|---|---|---|
| Potash | .0080 | .0102 | .0082 | .0087 |
| Phosphoric acid | .0036 | .0028 | .0028 | .0029 |
| Lime | .040 | .032 | .028 | .033 |

| D | 1 | 2 | 3 | Average. |
|---|---|---|---|---|
| Potash | .0100 | .0131 | .0080 | .0083 |
| Phosphoric acid | .0039 | .0036 | .0046 | .0037 |
| Lime | .021 | .042 | .028 | .030 |

*"Planter's Monthly," April, 1897.

| | G.1 | G.2 | H.1 | H.2 |
|---|---|---|---|---|
| Potash | .012 | .026 | .022 | .030 |
| Phosphoric acid | .0026 | .0030 | .0035 | .0035 |
| Lime | .052 | .040 | .028 | .038 |

In many cases a difference in the appearance of the cane is obviously due to the situation. In perhaps most instances the depressions or hollows in our mostly undulating cane-fields are more fertile than the elevations and sides; not unfrequently, however, the opposite is the case and the reason for this is less apparent. Two typical cases were chosen for analysis. G.1 and H.1 represent the sides of two different depressions and G.2 and H.2 the respective hollows. In both these cases the growth in the hollows was far behind that on the sides. On a rough, mechanical separation the samples taken from both hollows proved to contain more clay than those taken from the sides. Both the depressions are sufficiently drained, so that there is no stagnant water. Still the access of the air to the soil may be sufficiently checked by the clay and fine silt washed down from the elevations to provide favorable conditions for the growth of denitrifying bacteria.

All these analyses have not done more towards explaining the sterility of certain lands than those made two years ago. Bad drainage, acidity of soil or subsoil and unfavorable physical conditions are accountable for a proportion only of unsatisfactory results. In regard to the rest of the cases, where the soil appeared normal in its mechanical as well as chemical properties, the reason for their existence had to be looked for in another direction. The nearest cause that suggested itself was a possible damage done to the cane-roots by some injurious insect. The decision, whether this is the case or not lies, of course, in the province of the entomologist. A cursory examination of the soils and the cane-roots in such places did, however, not reveal any animal life that could not be found in other, normal fields.

The only side of the question which had so far been left untouched was the bacteriological one, and indeed experiments made in this direction promised a solution of a part at least of the difficulty. I will enumerate here some of the typical bacteria, whose activity in the soil principally affect the life of the plants. A number of micro-organisms, the most important of which is Bacillus mycoides, convert all kinds of nitrogenous organic matter into ammonia, which in its turn, is acted upon by the Nitrous ferment, a micrococcus known as Nitrosomonas, by which it is oxydized to Nitrous Acid. The oxydation is carried further by another, smaller bacillus, the Nicric ferment, or Nitrobacter, the final product being

Nitric acid, in which form the Nitrogen is ready to be assimilated by the roots. In order to test the activity of these bacteria, culture liquds containing ammonia and the other nutrients in small quantites, were seeded with equal quantities of the soils above described.

A, B, C, D, E, and F, seeded Oct. 18th, 1899. On Oct. 24th the nitric reaction was about equally strong in all the flasks. On Oct. 31st A and E showed but a trace of nitrite, B $\frac{3}{4}$, C 1/32, D $\frac{1}{8}$, F a trace; on Nov. 6th the nitrite had disappeared in all except B, which showed still a trace on Nov. 28th.

On Nov. 9th another series of culture flasks was seeded with samples of the same soils taken at a different time. E 1 is the same soil as E, but while E was added to the culture-liquid in the state it was brought from the field, E 1 had previously been air-dried.

On Nov. 18th almost all the ammonia had been converted into nitrous acid in A, B, E and F, while E 1 and F 1 only showed $\frac{1}{2}$, C and D $\frac{3}{4}$. On Nov. 28th nitrification was complete in A, C, E and F, while B showed only $\frac{1}{4}$ and D $\frac{1}{8}$; E 1 and F 1 $\frac{1}{2}$ of nitrate. On Dec. 15th nitrite was to be found only in B and D, and here it had disappeared on Dec. 27th.

On Nov. 19th three parallel series of experiments were started with soils from field A and B. The samples were taken from different spots and at different times, but A and B of each series at the same time. On Nov. 29th from $\frac{1}{8}$ to 1/16 of the original amount of ammonia was left in all the flasks; the rest had been converted into nitrous acid; 2 A and 3 A showed already $\frac{1}{8}$ of nitric acid. On Dec. 5th nitrous acid had disappeared in 2 A and 3 A, 1 A showed $\frac{1}{4}$, 1 B $\frac{1}{4}$ 2 B and 3 B $\frac{1}{2}$; the balance was nitric acid. A trace of ammonia showed still more or less perceptibly in all the flasks. On Dec. 12th no more nitrous acid in 2 A and 3 A, 1/16 in 1 A and 1 B and $\frac{1}{4}$ in 2 B and 3 B.

It will be seen from the above that the period used for the nitrification of a given quantity of ammonia is not the same in all instances. While there are no great divergences between A, C, E, and F, B and in a lesser degree D occupied much more time for the process. This time varied but little with samples of other normal soils taken at random. The different behavior of B and D attracts, therefore, all the more attention. During several years field B had received special attention; it was limed, ploughed and cultivated with special care with the same result, however; it was left to itself: same result; it had applications of high-grade fertilizers, with no evident beneficial effect.

These experiments show that, while there was not very much difference in the time occupied in the conversion of ammonia into nitrous acid, the oxydation of the latter into nitric acid was much slower in the case of soils B and D than in that of the others, so that it would appear that the nitrosogenic coccus is present in normal numbers and normal conditions, while the nitrogenic bacillus was lacking in activity. These observations, incomplete so far, still suggest a treatment promising success: i. e. inoculation with a culture of the nitric ferment as this preparation is not yet on the market, and reliable information as to results obtained by such treatment are not yet at hand, another remedy had to be looked for. For reasons, which will appear further on, green-manuring recommended itself as a probable remedy.

It may not be superfluous to show in an outline the action of a leguminous crop on the land and on subsequent crops, as reliable scientific data on this subject are of comparatively recent date:

In the first place stands the increase of the nitrogen contents of the soil, whether the crop is ploughed under or taken off. The *Leguminosae* draw their nitrogen supply indirectly from the air by acting in symbiosis with certain varieties of *Rhizobium Leguminosarum* (*Bacillus Radicicola*), micro-organisms, which settle on the roots, where they form the well-known nodules. Several of these varieties have been isolated by Prof. Nobbe and Hiltner of Tharandt in Saxony. Pure cultures of eight such varieties, each adapted to a certain species of Leguminosae, are prepared and sold under the name of "Nitragin" by the Farbwerke Hoechst a/M. Experiments made on German Agricultural Stations have given highly satisfactory results, increases in crops due to the inoculation of the soil with "Nitragin" ranging up to 400%.

2. Food, which is practically inaccessible to cane-roots, is brought up from the subsoil and thus rendered available for the former by the strong taproot and the generally strong system of roots peculiar to leguminous plants.

3. The roots play another, even more important part, inasmuch as the acids secreted therefrom accelerate the weathering or rendering soluble of the tied-up foods. Dietrich obtained some remarkable results in experimenting in this direction. He pulverized unweathered rocks, and while leaving some samples of this powder intact, he seeded others with Lupins, Pease, Wheat and Rye. He found the increase of material rendered soluble through the influence of the plants in the case of Lupins 20%, in that of Pease 16%, and in that of Wheat and Rye only $\frac{1}{3}$% and $\frac{1}{6}$% respectively.

4. By the growing and ploughing under of a crop with strongly developed roots and foliage it is evident that the soil is opened up, and to some considerable depth rendered accessible to the air. This in its turn brings about conditions

favorable to the growth of nitrogenic bacteria and at the same time unfavorable to that of denitrifying bacteria.

5. A great advantage, not to be overlooked, is the accumulation of the Bacillus Radicicola in the soil on account of its continued activity in assimilating nitrogen as shown by Liebscher. He holds, and he is supported by Winogradsky and Kossowitch, that these bacteria (*bac. radicic.*), which have left the nodules, retain the capacity to assimilate free nitrogen. He grew a crop of Sinapis alba on soil rich in bacteria, and found that its nitrogen contents were higher after deduction of the nitrogen taken off in the crop than they were before. Berthelot showed conclusively in his paper on "Recherches nouvelles sur les micro-organismes fixateurs de l'Azote," that the action of the *bac. radicic.* is not exclusively symbiotic, but that the bacillus is capable of assimilating free nitrogen independently of a leguminous plant.

As stated before, the success of green manuring depends in the first place upon the quality of the leguminous crop. As most of these plants prefer an open, sandy soil, it is to be expected that not all varieties will thrive well in this district. That the soil is well adapted for some varieties is shown by the rapid spreading of a Papilionacea with yellow blossoms, resembling the species Cytisus, growing in places where heretofore even Hilo grass could not make a living. I may here state that on a few occasions experiments on a small scale with green manuring were made in this district. These experiments ended with unsatisfactory or indifferent results, caused in all cases by a failure of the leguminous crop. This may be due to several causes, the most probable one of which is that the species of leguminosae selected were not suited to the climate or to the variety or varieties of bacteria in the soil.

It will therefore be advisable to experiment with several varieties of leguminosae on plants treated with simple and compound non-nitrogenous fertilizers. One of their first requirements is lime, best in the shape of carbonate, a constituent in which most of our lands are rather deficient. The lime would supplement and in a way assist the solvent action of the roots, the lime itself being a powerful agent in rendering nutrients available.

It may be well to point to the fact in this place, that the leguminosae are not the only plants which stand in such marked symbiotic relationship to lower organisms. A large number of other plants, among which the Coniferae stand foremost, have been shown by Frank to obtain part of their nitrogen supply through the medium of the white threads and accumulations, Mycorrhizae, which form on their roots.

Besides a number of varieties of Algae act as collectors of nitrogen when exposed to the air.

Having satisfied ourselves that the reason for the sterility of certain soils lies neither in its chemical composition nor in its mechanical condition, it becomes imperative that we should make ourselves acquainted with the biological side of the question. Favorable results could logically be expected from an inoculation of old land with new soil, with the view of introducing colonies of nitrosogenic and nitrogenic bacteria of greater vitality. Inoculations of lands for the purpose of improving leguminous crops have been practiced for many years, mostly with decided success. All this success has, however, been ascribed to the bacillus radicicola, the bacillus found in the nodules of the leguminosae.

It will be interesting to know the effect of a slight dressing of new land upon a soil a test of which shows a slow action of the nitroso- or nitro-genic bacteria or both. It is not to be overlooked that with such new soil numerous other micro-organisms are introduced, some of which could possibly do damage to a crop under the changed conditions. It was for this reason that Nobbe and Hiltner substituted their pure cultures for soil-extracts, and for this reason better success could be expected from an introduction of nitrifying bacteria in a pure state. Experiments in this direction will be made as well as in that of green manuring. This latter practice has been in use in another district of this island for a considerable time with encouraging results.

Since the above was written, the very lands which at the time were commonly called "played out" or "exhausted," have given magnificent yields, as soon as certain other varieties of cane were introduced. This proved conclusively that the falling off in yields was not due to a lack of nutrients in the soil, but to the inability of the roots of the old variety to assimilate the food, caused probably by a slackening of the activity of the micro-organisms, which serve as go-betweens between the soil's food supply and the plant. E. E. H.

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## *METHODS OF OBTAINING WATER SUPPLY FOR SUGAR PLANTATIONS IN THE HAWAIIAN ISLANDS.*

By J. N. S. Williams.

What is now known as the Territory of Hawaii, United States of America, consists of a group of islands lying in the Pacific ocean, 2,100 miles southwest from San Francisco, in longitude 155°-161° west and between the 18th and 22nd parallels of north latitude, just within the tropic of Cancer and in the path of the northerly trade winds.

The principal islands of the group are Kauai, Oahu, Molokai, Maui and Hawaii, also some small and unimportant islands near by.

Geologically this group of islands is peculiar and is supposed to be in connection with a long chain of islands stretching from northwest to southeast for some thousands of miles in the mid-Pacific ocean, the mountain tops of a submerged continent.

Each island in the group, with the exception of Kauai, consists of two mountain ranges of volcanic origin connected by an interval of comparatively flat and low land, these mountain ranges cross the path of the prevailing winds and form barriers to the clouds brought down, which condense and precipitate a heavy rainfall on the mountain slopes on the windward sides of the various islands.

This heavy precipitation, amounting to upwards of 400 inches per annum in places, has caused great erosion of the steep mountain slopes, which on the exposed side are seamed with tremendous chasms, some of them many hundreds of feet deep.

This process of erosion is still going on, and has had the practical effect of sweeping a great proportion of the surface soil of the windward coast down to the flats and into the sea.

For this reason the best and most continuous stretches of lands are on the flats connecting the mountain ranges, and on the leeward sides of the islands. Since the rainfall on this side, while extremely heavy at times, is intermittent and due to a wind which seldom occurs, the land is not much cut up by gulches or canyons nor yet has it been denuded of surface soil to such an extent as prevails on the windward side, and is much more fertile and productive.

These lands are composed partly of volcanic mud ejected from volcanoes (now extinct) and partly of decomposed lava resulting from ancient volcanic action, and are covered by very scanty vegetation until water is brought out to them.

When the growing of sugar cane was first started on these islands, some forty or fifty years ago, the plantings were made on the windward side of the islands to take advantage of the rainfall, and it was not until some years after the inception of the industry that it became evident that the rainfall was not regular enough, excepting in some few places, to produce the best results in cane culture; and hence the first attempts at irrigation, accomplished by damming up streams and leading the water out by means of ditches to the head of the cultivated lands.

One successful ditch after another was put through and the sugar industry prospered greatly, giving incentive to works of collossal magnitude, consisting of miles of ditches and thousands of feet of inverted siphon pipes for carrying water across gulches which could not be bridged nor yet got around by flumes.

These siphon pipes are of sizes varying from 18 inches in diameter to 48 inches in diameter and are made of riveted wrought iron or steel plates of strength sufficient to carry static pressure due to heads of 500 feet and upwards.

These pipes are made in sections and riveted in place; the fall given to the siphon pipe is usually one foot in one hundred feet of pipe measured on the curve; that is, the bottom of the entry ditch will be one foot in one hundred feet of pipe higher than the bottom of the delivery ditch.

The size of pipe is calculated so that the velocity of the water through it shall not exceed from 3-7 feet per second.

This fall in the pipe is more than is necessary to pass the water at the given speed, but is allowed to compensate for the collection of mud, stones, etc., in the bottom of the pipe and also for any growth that may form on the interior.

These pipes are always fitted with manholes and waste valves at the lowest points for the purposes of inspection and cleaning and are kept painted with an asphalt composition on the outside.

It sometimes becomes necessary to make close calculations on the delivery of water in iron inverted siphon pipes, and the following useful formula, based on that of Trantwine, has been successfully used in such instances.

Formula for finding the *total* head in feet that must be given to a riveted steel or iron pipe of a given diameter, coated inside with asphaltum, to enable it to discharge a given required quantity: (Adapted from formula Art. 3, page 248, 1885 edition, Trantwine's Civil Engineers' Pocket Book):

Let H=total head or difference in level between the bottom of entry and delivery ditches serving an inverted siphon pipe.

D=required discharge in cubic feet per second.

L=length of pipe in feet measured on the curve.

d =diameter of pipe in feet.

c =Constant=for asphalted riveted pipe 3496.

$$H=\frac{D^2 \times [L + (d \times 54)]}{c \times d \times (d^2 \times .7854)^2}$$

The constant c=3496, is deduced from the results of observations made by Mr. H. C. Perry, C. E., in charge of the ditches and pipelines on the sugar estate belonging to the Hawaiian Sugar Co., of Makaweli, Island of Kauai.

These pipelines are 40 inches diameter inside the small end of the courses of pipe, and deliver 55 cubic feet of water per second, measured over a weir situated in the delivery ditch.

In all siphon pipes used in this country the radius of curve is so great that the pipe can be taken as straight without appreciable error.

The formula gives results which compare closely with observed discharges in several pipelines varying from 20 inches to 48 inches diameter and from 500 to 2,500 feet in length.

No observed data are available for pipes longer than about 1,000 diameters.

Of late, tunnelling as a means of conveying water in a country very much cut up by gulches has been successfully adopted, particularly in districts where the canyons are very deep and close together. The tunnels are driven on a grade and follow the general course of the canyons, keeping some little distance back from the face of the bluffs; breakthroughs are driven from the tunnels to the face of the bluff as a means of ventilation, for the discharge of rock and for the purpose of catching small streams which fall down the face of the cliffs, especially near the heads of the gulches. (See sketch of cross section of tunnel herewith.)

A special instance of this work is shown in the Olokele ditch just completed for the Hawaiian Sugar Company above mentioned; and in the Nahiku ditch for the Hawaiian Commercial & Sugar Company, of Maui, Hawaiian Islands, now under construction, both of which ditches, with all work connected therewith, are under the supervision of M. M. O'Shaughnessy, Esq., C. E. (1).

Where the tunnels pass through seamy rock the bottom and sides are lined with cement mortar, 1 part cement to 4 parts of sand in ordinary rock the mud brought down by the water in freshets will, in a short time, tighten the tunnel bottom so that no leakage will occur.

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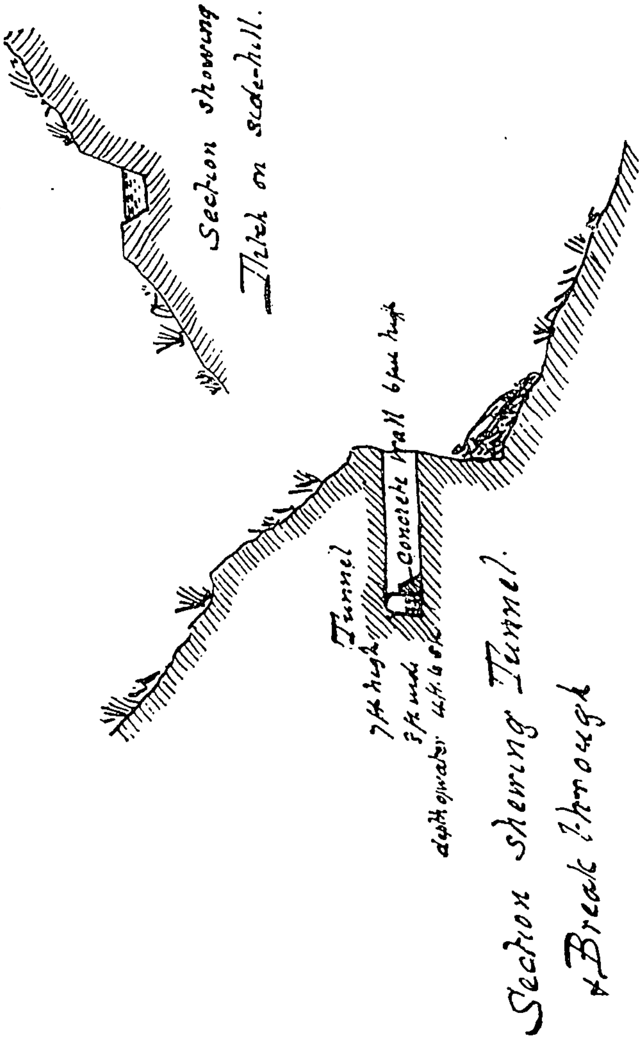
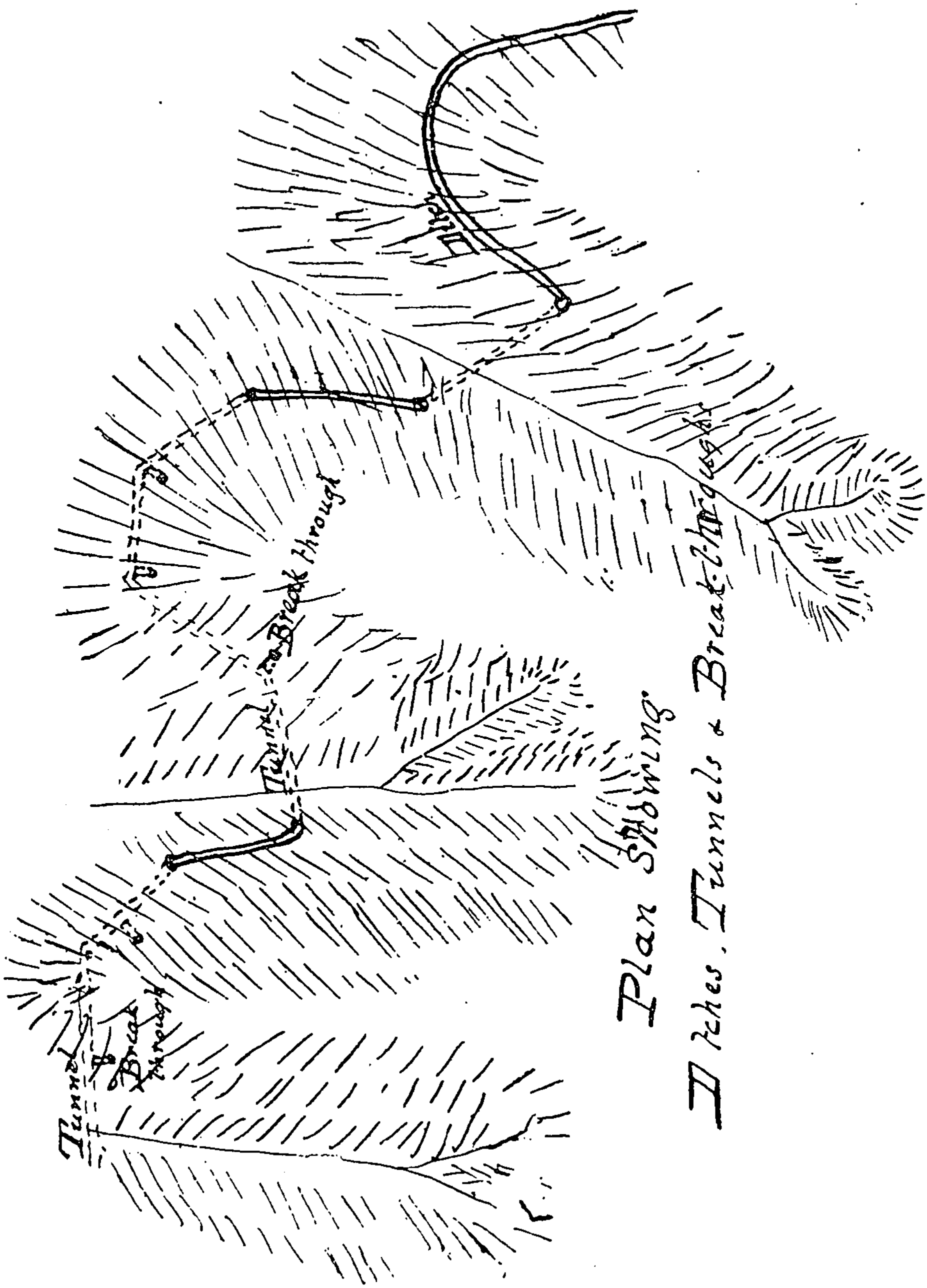
(1) The author is informed by the Hon. H. P. Baldwin that this method of conveying water was first adopted in this country when the Hamakua Ditch Co.'s line on the Island of Maui was constructed some 25 years ago; since then this very bold scheme has been improved up to such an extent that in the above mentioned ditches no siphon pipes or flumes (which are liable to destruction by cloudbursts or violent rainstorms), have been used, and a large proportion of the entire ditch line is tunnel.


Section showing
Concrete wall 6 feet high
Tunnel
Section shewing Tunnel
& Break through


Plan Showing
Ditches, Tunnels & Break-Throughs
Tunnel to Break through
Tunnel & Break through

The ditches are given a grade of 1 foot in 1,000, sometimes a little more, depending upon the scouring action of the water on the ditch bottoms.

As regards the construction of the ditches and flumes where used, the ordinary practice is followed, special care being taken at the entries to siphon pipes to fit substantial and large waste gates, so that in event of heavy local rain storms the excess of water shall escape away from the head works of the pipeline.

In general work on a sugar plantation that uses irrigation, the quantity of water required to properly irrigate 100 acres of land under cane cultivation is one million gallons per 24 hours, and as large plantations have from 7,000 to 12,000 acres of land in cane, from 70 to 120 millions of gallons of water per 24 hours is required.

Some plantations are situated in districts where no surface water is available, others again cannot obtain a sufficient supply from their ditches and catchment areas, so to supply their needs, sinking for water has been resorted to.

On the island of Oahu an underground reservoir of water which could be tapped by artesian wells was discovered some years ago; this water rises at this place some 30 feet above the level of the sea and is found at depths varying from 400 to 1,200 feet.

Pumping machinery of great capacity was put down and the underground supply drawn upon for use on the plantations situated within the artesian area.

At the present time the daily water pumped from artesian wells on the island of Oahu reaches about 300 millons of gallons, some of it lifted upwards of 500 feet in height.

This condition of an artesian supply does not appear to exist on any of the other islands in the group, and when pumping is resorted to, open wells or sumps are excavated, the underground supply resulting from rainfall on the mountain sides percolating through an upper broken stratum and retained by a lower stratum of impervious rock.

These sumps are excavated to about 20 feet below sea level, tunnels are then driven on the lower stratum directly inland, opening up the water-bearing rocks, and the supply thus obtained is pumped from the sumps through very long pipe lines to the levels required on the cultivated areas.

To avoid the heavy expense of long pipelines, there are three instances of shaft-sinking at the upper levels of the cultivated lands down to sea level, and regular underground pumps of mining pattern installed, but these have proved so expensive in first cost and up-keep that there is no encouragement to repeat the experiment.

One of the largest stations of this kind is at Kihei, on the island of Maui, where the shaft is 300 feet deep and two pumping engines of a combined capacity of 17 millions gallons of water per day lifted 400 feet high, are situated in a very large chamber excavated in the rock; an abundant water supply is found at sea level, but the expenses of operation are very heavy in comparison to those of surface pumping stations delivering water through long pipelines.

The machinery installed in the various pumping stations is of the most modern and complete make obtainable at the present day, and as in no other part of the world are such mechanical irrigating plants in existence, a more than passing notice may be of interest.

The plantations that pump all or part of their irrigation supply are situated as follows:

| | | | | | | Millions |
|---|---|---|---|---|---|---|
| Island of Kauai, 3, | approx. | deliv. | 24 hours | in gallons | ... | 75 |
| " Oahu, 6, | " | " | " | " | ... | 360 |
| " Maui, 5, | " | " | " | " | ... | 150 |
| " Hawaii 2, | " | " | " | " | ... | 10 |
| Total delivery per 24 hours, gallons, about | | | | | ... | 595 |

The average height to which this water is pumped is about 200 feet, and the total power developed to deliver this enormous quantity of water is over 20,000 horse-power.

The stations are divided into units of various capacities, situated at spots most convenient for obtaining the water The largest units deliver from 10 to 12 million of gallons per 24 hours, and a station may have as many as four units; the majority have only one.

The pumps themselves can be divided into three classes: Impeller pumps, such as centrifugal or other types of rotary pumps; Multivalve pumps, such as the Worthington and others in which piston or plunger pumps draw and discharge water through large numbers of small valves set in suitable suction and discharge chambers, which valves open and close by the water pressure, and pumps having mechanically operated suction and discharge valves of which only one type, the "Reidler" Patent, constructed by the Allis Chalmers Company, of Chicago, has been operated in this country.

The pumping stations are fitted with all kinds of boilers, of which two makes stand first in point of numbers installed —Babcock and Wilcox water tube boiler and the Sederholm fire tube boiler—and there are all kinds of fuel and labor saving arrangements. Green economizers in the flues, arrangements for coal handling, automatic damper regulators, etc. And, as a result, exceedingly high efficiencies are obtained in ordinary work.

The engines driving the pumping machinery are almost all of the Corliss type two cylinder compound, three cylinder triple expansion, and four cylinder triple expansion of the very best make and finish and fitted with all modern appliances in the shape of condensers, feed water heaters, and in one instance the latest ideas in superheated steam have been applied.

The mechanical efficiencies obtained on the various systems of pumps are as follows:

Centrifugal pumps delivering to 50 feet head, from 45 to 55 per cent.; impeller or rotary pumps, from 60 to 75 per cent.; multivalve pumps, from 75 to 85 per cent., and mecanically operated valve pumps from 85 to 90 per cent.

In one mechanical effciency test made by the author on a Reidler triple expansion pumping engine, delivering water at 375 feet above the level of the water in the sump, at the rate of 10 million gallons per 24 hours, and the water delivered by pump measured over a weir especially made for the purpose, the remarkable figure of 91.85 per cent. was obtained; that is, of the horse-power developed on the main engines 91.85 per cent. was expended in doing useful work on the water delivered.

The test was undertaken for the purpose of determining the slip or back lash of the water in a pump having mechanically operated suction and discharge valves, which in this instance was found to be ¼ of 1 per cent.

The necessity of high economy in pumping machinery in this country is seen when the cost of coal at from $7.00 to $9.00 per ton delivered into the furnace is considered.

A large number of pumping stations are now operated with California crude oil as fuel, which is furnished to the various stations at about $1.50 per barrel of 42 gallons; at this price oil is about equal in value to coal at $6.00 per ton, but as oil leaves no residue nor yet soots up the tubes or economizers as coal does, the economy in labor by using oil instead of coal is very marked. In a large pumping plant formerly employing eight firemen and coal passers per day, and two water tenders, the eight men have been cut out entirely, the work of keeping steam with fuel oil being done, and done easily by the two water tenders in addition to their other duties.

It, however, is clear that such an economy is obtainable only in large plants, as in small plants, operated by one man on a watch, no economy in labor is possible.

The burners used for crude oil are of various kinds and makes, but the results obtained by each are about the same, 6 pounds of ordinary crude oil of 18 Beaume (minus scale) being equal to 10 pounds of ordinary coal.

When the use of oil was first contemplated it was expected that the boilers would suffer from the intense heat generated in the furnaces, but this expectation was not justified, as all experience here goes to show that the life of a boiler will be just as long with oil as with coal for fuel, provided that the proper furnace arrangements are adopted.

By the courtesy of the Hon. H. P. Baldwin, General Manager of the Hawaiian Commercial & Sugar Company, the writer is enabled to give the following figures for the cost of pumping water to different elevations by the following machinery:

| | | | | |
|---|---|---|---|---|
| Pump Plungers | | $11\frac{7}{8}$ in. diameter | x 42 | in. stroke |
| Steam Cylinders | H. P. | 19 in. " | x 42 | " |
| | I. P. | 33 in. " | x 42 | " |
| | L. P. | 50 in. " | x 42 | " |

The whole forming a Reidler triple expansion pumping plant.

Sederholm boilers, Green's economizer, California crude oil for fuel, steam pressure 180 inches above atmospheric pressure.

Revolutions of Engine per minute, 54.

Delivery in 24 hours at this speed, 9 million gallons.

| Elevation of Delivery | Cost per Million Gallons |
|---|---|
| 100 feet | $ 7.85 |
| 200 " | 11.57 |
| 225 " | 12.50 |
| 250 " | 13.44 |
| 300 " | 15.30 |
| 350 " | 17.17 |

which figures include superintendence, labor, fuel, supplies and repairs during one year, which contained 240 pumping days. The figures would be considerably modified if continuous pumping were employed, but as occasional rain storms occur, the pumps are only operated when required.

The economy of such a pumping plant is high; one horsepower being produced for the consumption of 1.12 lbs. of oil per hour, which, at the rating of 6 lbs. of oil being equal to 10 lbs. of coal in ordinary work, is equivalent to 1.87 lbs. of ordinary coal horsepower per hour.

As a rule pumping is considered to cost 50 per cent. more than ditching, but since a ditch depends on rainfall for its supply, there is an element of uncertainty about it. Pumping, on the other hand, is very sure, since the underground supply of water is practically inexhaustible, and even during severe droughts, when the ditches are nearly empty, the pumps are always able to furnish water.

The most conservative practice in irrigation works for sugar plantations, where possible is to have both systems, so that whichever way the barometer goes water is available for the crops in the ground.

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## *IRRIGATION IN HAWAII.*

By M. M. O'Shaughnessy.

The development of irrigation projects has been prosecuted with great vigor by private corporations owning sugar estates in the Hawaiian Islands during the last ten years. No aid for this work has been received from either the local Territorial Government of Hawaii or the National Government at Washington. What was formerly arid and unproductive soil covered by wild brush and pasturing a few cattle, has, by the application of water at a heavy expenditure of money and enterprise, been converted into productive sugar-cane land.

### RAINFALL.

The rainfall of the Hawaiian Islands is very local and peculiar in its distribution. The trade-winds blow off the ocean from the northeast, and on this slope a rainfall of from 60 to 200 inches a year is quite common, the intensity varying with the altitude and local configurations, while on the lee sides the rain is often as light as from 10 to 15 inches. The islands as a rule are quite rugged, varying in altitude at their central hightest points from 3,000 to 10,000 feet. The windward sides are covered with a dense brush which remains green throughout the year. On the northeast slope of Maui the maximum precipitation is at an altitude of 1,500 feet, often as great as 400 inches a year at Nahiku, while at sea level and higher up the mountains it is only a third of this quantity.

### USES OF WATER.

Water is used for irrigating the sugar cane, the annual crop of sugar each year amounting to 400,000 tons, which averages $70 a ton, or $28,000,000. One-half of this is due to the development of irrigated plantations during the last twenty years. The other 200,000 tons is raised on rainfall plantations, which are very uncertain in their output, owing to the precarious rain conditions prevailing.

## ANCIENT WATER RIGHTS.

The population of Hawaii was very dense in prehistoric times, as the remains of old houses and fields bear convincing testimony. Nearly all the streams were led out by ditches, called "Auwais," and the water used for growing taro, the national food, and other vegetables. The ditches were excavated in surface earth and maintained by joint users, each of whom had to devote so many days each month towards repair. The water was also distributed between its users by set rules and at stated times; each district with its branch ditch getting so many hours' flow of the stream.

The land thus cultivated was always in the vicinity of the stream as no long ancient conduits were built, and was styled "taro" land in contrast to "kula" or dry land, which carried no water rights.

The native Hawaiians have protected with the greatest zeal their water rights through taro land, which the gradual growth and expansion of sugar plantation interests have tended to absorb.

## MODERN IRRIGATION.

The present water supply of the Islands is derived from two sources:

(1) By pumping ground or artesian waters from wells and sumps, excavated near the sea shore. The pumps are driven with either coal or oil as fuel, or by electricity generated from water power.

(2) By gravity, from the natural flowing streams, the impounding of flood waters of same; and by the interception of ground water by tunnelling.

One of the most striking discoveries the Continental engineer has to experience is the extraordinary productiveness of some of the island water sheds, which destroys at once many preconceived theories as to what run-offs should be. The Waihee shed on Maui, with an area of about four square miles, yields a daily minimum flow of 17,000,000 gallons, while the Olokele shed on Kauai, with an area of about eight square miles yields a minimum flow of 40,000,000, and a mean flow of 70,000,000 gallons in twenty-four hours. Each of these water sheds is particularly and favorably situated for precipitation with brush-covered steep slopes, and with almost daily rainfall.

Nearly all the Hawaiian streams respond very quickly to rainfall, rising and falling quite rapidly; while those with a good dense brush covered water shed hold the volume in streams almost constantly above a certain minimum.

## OAHU ARTESIAN SUPPLY.

The artesian supply of the island of Oahu is the most peculiar and the most generous that we find in any country of such a limited area, the island being only about twelve miles wide, north and south, by thirty-five miles long, with mountain ranges near its north coast 3,000 feet high. It yields daily from wells and sumps 250 to 300 millions of gallons without any apparent diminution of the supply, the source of which is in a porous strata found at a depth of from 400 to 800 feet below the sea level. The static level of the water in the wells penetrating this formation varies from an elevation of 40 feet above the sea level at Honolulu to 22 feet at Ewa plantation, sixteen miles westerly. Excessive pumping or prolonged droughts vary somewhat this level which is always quickly restored on cessation of affecting conditions.

The islands are all of a porous stratified lava formation formed in layers by successive emissions from the ancient central cones which now form the summits of the islands. The water supply in the artesian strata near the sea is sustained by mountain preciptation, and the intimate connection between the mountains and the wells is proven by the sudden discoloration of the water in the latter some hours after heavy rainfalls in the mountains. The artesian condition of the Oahu strata is caused by a tight coral and clay cushion which rests on the foreshore and prevents the water escaping to sea. In none of the other islands, owing to the absence of this necsary formation, is artesian water found; the pumps being fed from sumps excavated from five to eight feet below sea level in all of which the water fluctuates from one to two feet, corresponding with tidal changes which vary in this tropical region from two to four feet between low and high waters. The depth to which it is safe to lower the static water level in Oahu wells by pumping has been tested on each plantation. The rapid increase of salt per gallon by excessive pumping and the consequent lowering of the water level, forbids extreme practice in this respect. The Oahu artesian waters carry eight to twenty grains of salt per gallon in normal condition, while water with salt as great as 60 grains per gallon will successfully irrigate sugar cane. The pumping stations are usually fed by a series of 12-inch wells spaced 50 feet apart and connected by larger pipe with the suction ends of the pump placed at as low a level as practicable. One million gallons has been pumped uot of each well thus spaced, and ten wells have been found sufficient for a 10,000,000 gallon pumping engine, which is the usual size of unit employed.

The water is usually pumped through a 24-inch or 30-inch discharge pipe, varying with the size of the pump and the head. Most of the water is delivered below an elevation of 300 feet, though in a few instances lifts as great as 450 feet have been pumped against. The uncertain and fluctuating prices of sugar, the cost of fuel and other expense practically preclude all profitable pumping above 400 feet. The work of pumping 10,000,000 gallons daily to 300 feet elevation with ordinary pumps in service will consume 15 tons of coal; which at $8 per ton, would mean $120 per day for fuel expense alone. The cost of labor, lubricants, depreciation, etc., have to be added to get the total cost. Owing to the extreme fertility of the soil as many as eight and twelve tons of sugar per acre are raised, which yields a return of about 10 to 12 per cent. on the investment. Five plantations on the island of Oahu, namely: Kahuku, Waialua, Ewa, Oahu and Honolulu, have a pump capacity of 287 million gallons daily with a water horse power of 11,847 and draw water from 195 wells. Waianae furnishes the novel feature of using the fall in some gravity water found in its higher levels (500 to 1400 feet) to develop power, after which the water is again used for irrigating the lands lower down, while the power is transmitted to electrically driven pumps near sea level to lift ground water from wells to the 150 foot level. Maui comes next with a pump capacity of 140 million gallons daily of 6945 horse power, the water being drawn from sumps. Kauai has 55 million gallons daily pump capacity with 2033 horse power, drawing principally from sumps, while Hawaii, which is the largest of the islands, has only one pump of 7 million gallons' capacity, of 412 horse power, pumping from a shaft and sump.

The steep slopes, porous soil and high elevations of the plantations have prohibited irrigation on the island of Hawaii, which is the most recently formed geologically of all the islands.

No flowing surface stream exists for a distance of two hundred miles on the coast, from Kohala southerly around to Hilo. The soil is of so porous a nature that it passes the rainfall through like cinders and allows no surface accumulations of water. It has the volcanoes Mauna Loa and Kilauea intermitently active, which emit two distinct varieties of lava; "Pahoehoe," which is heavy and compact, having sometimes a smooth glassy and undulating surface; and "A-A," which is much lighter in specific gravity than the former, often floating on its surface during flows and breaking up into all kinds of disintegrating masses on cooling.

## PUMP INSTALLATION.

Experience with the direct-acting, slow-moving pump of the Worthington type has not been encouraging. All new pumps now installed are of the high-speed fly-wheel type, which consume much less coal; and where all fuel has to be expensively imported, the greatest economy in this direction has to be exercised. The pumps are nearly all installed in concrete-lined pits 36 to 50 feet square, excavated to the water level, while the boiler plants are on the ground surface above. In three instances at Oahu, Kihei and Kohala, the experiment of sinking shafts from the ground surface 200 to 300 feet down to the water level, and excavating pump compartments at this level have been tried. The difficulties of ventilation and the expense of shafts and chamber have more than balanced in each instance the saving of cost of placing delivery pipe on the surface and the friction lost in same, which were the principal inducement for installing this system. The ground water has also been found as brackish in such a shaft two miles from the sea, as water found in wells 100 yards from the beach.

Outside of Oahu all pumping has to be very cautiously prosecuted as too great a lowering of the sump level will increase the quantity of salt in the water, running it up to 100 or 200 grains per gallon, which renders it unfit for irrigation purposes, as it incrusts the soil with salt and damages the cane plants. Owing to the great porosity of the rock formations and the heavier specific gravity of the sea-water, the tendency of the latter is to force itself inland where any vacuum is created by excessive pumping and consequent lowering of ground water.

## GRAVITY SUPPLIES.

All available streams are now tapped by ditches on Maui and Kauai. The first was built on the windward side of Maui in 1878 by Mr. H. P. Baldwin and Mr. S. T. Alexander. The next was built in the same section by Mr. Spreckels in 1879-1880, under the supervision of Mr. H. Schussles of San Francisco as engineer. It is about thirty miles long ,of 50 million gallons daily capacity, and delivers the water at an elevation of 250 feet, and is known as the "Haiku" ditch. This ditch was intercepted by a new work called the "Lowrie ditch" in 1900, which delivers the water at an elevation of 450 feet. The writer has just finished a new aqueduct, known as the "Koolau ditch," which taps all the Nahiku rain belt at an elevation of 1250 feet and discharges into the older and lower ditches. It is ten miles long, seven and one-half miles being in tunnel and two and one-half in open ditch and flume. The tunnels are all in solid rock, eight feet wide and seven feet high, with a daily capacity of 85 million gallons. Owing to the extreme porosity of the lava rock, four and one-half miles of concrete lining six inches thick is used in the tunnel to prevent seepage. The work was all done by Japanese with hand drills; ore cars were employed in moving the excavated materials, and it has cost finished about $7 per lineal foot. The Japanese make excellent miners and rock men, and, owing to their small size, it was practicable to work four in a face, and by working three 8-hour shifts, the whole work had to be completed in eighteen months from the date of commencement, April, 1903. There are thirty-eight tunnels on the work, averaging each 1000 feet long, the shortest being 300 feet, the longest 2710 feet. The country was so steep and precipitous that little ditching could be employed, and it was necessary to make four and one-half miles of wagon road and eighteen miles of stone paved pack trails to facilitate during construction the transportation of supplies. About 4000 barrels of cement and 100,000 pounds of giant powder were used. In all ten mountain streams are intercepted, which are admitted into the main aqueduct through screens of grizzly bars spaced three-quarters of an inch apart.

The Honokahau ditch, with 30 million gallons daily capacity, has just been finished on west Maui. It is thirteen and one-half miles long on a grade of five feet per mile and has 200 feet of 36-inch syphon pipes and three and one-half miles of tunnelling, and has cost $185,000. It delivers water at 700 feet elevation.

All the streams on the island of Maui are now tapped by ditches, including the Waihee stream, previously referred to at Wailuku.

## MAKAWELI DITCH.

The "Hanapepe ditch," Makaweli, Kauai, was built by Mr. Baldwin in 1890, to tap the stream of that name. It has 7040 feet of 40-inch riveted steel syphon pipe, 1013 feet of tunnels, 14,618 feet of flume, five feet wide by forty inches deep, and ten miles of ditching on a general grade of six feet per mile and carries 35 million gallons daily. The use of wooden flumes in tropical countries is not advisable, as repairs have to be frequently made owing to the rapid decay of the wood. This ditch delivers water on the plantation at 450 feet elevation; and a new one just built and completed under the writer's supervision, known as the "Olokele ditch," delivers water at an altitude of 1075 feet and has a daily capacity of over 60 million gallons. It involves eight miles of 7x7 feet tunnels, five miles of ditching; and it has cost completed about $360,000. At one point a drop of 228 feet was obtained which it is proposed to utilize for electric power purposes in operating the plantation mill and railway. Makaweli plantation has now the best gravity supply on the islands, with a daily minimum from its two sources of 65 million gallons. It is proposed later on to store the freshet water in reservoirs and use them as balancing mediums to restore the supply when the streams run low. Owing to the steep land slopes, six to fifteen degrees, it is very difficult to select favorable reservoir sites, except in the center or back of old volcanic cones.

Many streams have been diverted and many ditches made during the last five years on Wailuku and Pioneer plantation on Maui, the Oahu and Waialua plantations on Oahu, and the Koloa, Makee and McBryde plantations on Kauai, but for the reasons before stated practically no stream diversion for irrigations has been made on the largest island, Hawaii, except the development of water for cane fluming purposes at Olaa, Pahala and Hutchinson.

## GROUND WATER.

The most novel development in water supply has been the discovery of water by driving tunnels into the lava formation at high altitudes at encouraging localities. It is very difficult to predict what success will reward any outlay in this field, as the results are all problematic. A two-million gallon flow has been developed at an altitude of 1400 feet at Waianae on Oahu island, by a five hundred foot tunnel; while at Lahaina, on Maui, at an altitude of 2600 feet, a six-million gallon daily flow has been developed by 2600 feet of tunnel in a formation whose exterior surface showed no signs of water such as springs, etc., and this volume has kept practically constant for two years, fluctuating slightly with the rainfall on west Maui mountain in its immediate vicinity, 3000 feet higher. On the other hand in the fifteen miles of aqueduct tunnels cut under my supervision in the past two years no ground water in any quantity has been intercepted except an occasional drip from tunnel roofs through porous stone.

## DUTY OF WATER.

One million gallons of water per day is the quantity found necessary to irrigate each hundred acres. Sugar cane is grown in furrows about five feet apart, into which the water is turned from the field ditches. When the seed is newly planted the water is turned on every three or four days, but after that an application of once each ten days is considered sufficient. The above quantity if applied uniformly to the whole surface would make a depth of 134 inches in one year excluding rainfall, and evaporation, which is possibly fifty inches in most of the irrigated properties. It means the application, for a crop period of one year and a half of 22,800 tons of water per acre to produce 50 to 80 tons of cane, which would appear to be excessive.

It is safe to presume that leaky reservoirs, ditches and unequal and wasteful distribution prevent the application of not more than one-third of the above quantity of water to the roots of the cane where its value would be utilized.

Economies of various kinds in the application of water are now being gradually introduced which will enable the best results to be obtained. Nearly all the water so far developed has been used by the owners on their own property. Lately surplus has been disposed of to adjacent owners at a flat rate of from $8 to $10 per million gallons. Great credit must be given the American pioneers who have developed such splendid supplies under so many adverse conditions in the past twenty years in those remote islands in the Pacific. By no other people except perhays the Mormon settlers of Utah has so much enterprise been displayed and so many sacrifices been made in developing the nonproductive country into one of pronounced prosperity.

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## *DIFFERENT HEATING SYSTEMS IN SUGAR MANUFACTURE.*

By A. Sillinger.

The principal burden in the working expenses of a raw sugar factory and sugar refinery is undoubtedly the coal bill.

It is, therefore, the object of the expert, dealing in this branch, to obtain as favorable a result as possible by a systematic control in the boiler house through the economical use of fuel and a rational employment of the steam needed in the various heating systems.

The extent to which the different forms of steam heating apparatus supply present demands forms the object of the following notes.

It is obvious that in the heating of a liquid the heat is communicated from its source to the liquid through the medium of a partition wall.

Saturated steam serves as a source of heat for the warming up, steaming and boiling to grain of juices, and transfers its heat to the juice through a metallic partition according to the formula $Q=F.D.k$ in which $Q$ = quantity of heat transferred; $F$ = area of transmission surface of the heat $D$ = difference between the temperatures of the steam and the liquid to be heated (*i. e.* the fall in temperature); $k$ =

coefficient of heat transmission. Suppose F = 1 square metre, D = 1° C., then it is clear $k = Q$, and thus we can estimate the transmission coefficient for that amount of heat which is furnished by the steam in the unit of time (hours, minutes, seconds) through a partition having a surface of 1 square metre.

The coefficient of transmission is not constant; it depends in the first instance on the coefficient of thermal conductivity possessed by the different materials which go to form the heating system; further, on the shape and thickness of side of the apparatus and finally on the extent to which the temperature falls.

The coefficient of thermal conductivity is defined as the amount of heat which passes in a unit of time from one side to the other of a cubic metre when the difference in temperature between the sides amounts to 1° C. Consequently it also varies with different substances. Silver, for example, gives 100, copper 72, brass 25 to 28, iron 16, and lime salts, which form incrustations on the heating tubes, 0.5 to 1 calories. For a given thickness of partition the transmission coefficient is proportional to the coefficient of thermal conductivity. Since the transference of heat depends on the difference in temperature between the heating steam and the juice to be treated, the coefficient of transmission increases in proportion to this difference in temperature and to the pressure of the steam. Again, the fall in temperature depends on the expansion of the steam and on the concentration and viscosity of the juice. As the steam is cooled by expansion, the difference in temperature becomes less, and the coefficient of transmission falls in the same proportion.

With increasing concentration the specific heat of the liquid increases, while the fall in temperature and thereby also the coefficient of transmission decrease. These points were established by experiments carried out by Mollier.

The development of steam can take place in two different ways. Either bubbles of steam are produced on the upper surface of a liquid at a somewhat higher temperature than the freezing point, in such a manner that the individual molecules under outside influence, such as a draught of air, separate from the agitated surface of the liquid in the form of steam and diffuse in the atmosphere—"the liquid evaporates;" or else they are formed within the liquid itself and escape more or less violently from the surface of the liquid—boiling begins. According as the steam bubbles produced underneath the surface of the liquid stand in relation to the barometric pressure and the juice column, they require a certain pressure to overcome them; this increases from below. Through this pressure the steam produced becomes saturated and absorbs no more heat, so that care must be taken for its diversion or else the transference of heat will be interrupted. Either this arises naturally, since the steam, being specifically lighter, rises and carries the juice with it in its upward motion whereby a colder portion takes the latter's place, in other words a natural circulation exists, such as is necessary for the transference of heat; or else an artificial movement by means of stirring apparatus is carried out if the concentration increases.

The saturated steam, on yielding its heat to the liquid, condenses and cools off. It is therefore needful to drain off the condensation water rapidly so as to avoid the temperature of the subsequent steam being reduced and its contact with the whole heating surface becoming disturbed. With these considerations it is therefore evident that a steam heating system shall possess the following characteristics:

1. It must be made of good heat-conducting material of which the thickness of partition shall be as small as possible.
2. The heating surface shall be as large as possible and must have full contact, on the one side with the heating steam, and on the other with the liquid to be heated.
3. The difference in temperature between the steam and the liquid to be warmed, and the pressure and flow of the steam must where possible be considerable.
4. The circulation of the juice, whether artificially or naturally produced, must be carried on vigorously.
5. Rapid draining off of the ammonia and condensation water is necessary.
6. Low juice column and large surface of juice desirable.
7. The greatest transfer of heat shall take place in the lowest strata of the juice.

In these respects we wil now see how far the heating systems existing at the present day in sugar manufacture fulfill these requirements.

## I. The Heating Tube.

The spiral heating tubes are generally formed from copper pipes of from 80 to 110 mm. dia., finished in a series of coils and inserted into the vessel to hold the liquid to be heated up. The steam flows from top to bottom, transfers its heat to the fluid through the intervening medium and then condenses.

In the lower coils of the pipe, where essentially the greatest transfer of heat should take place, we find the condensation water collecting; the latter not only cools the heating surface it comes in contact with, but also throttles the flow of steam whereby the liquid lying round the lower coils gets less heat, the circulation is rendered less vigorous and incrustation is encouraged. The difference between the upper and lower resistance varies according to the height of the spiral column, and in the former instance is practically nil. Here the escaping steam bubbles carry the juice along with them and under high steam pressure their action is so violent that the liquid in the vessel rises and care must be taken to provide it with ample room to so ascend.

The tubes can only be heated with live or return steam since they have no arrangement for drawing off the ammonia.

From the force of the steam, the tubes are easily rendered leaky, while repairs are impossible during the working operations.

Yet in spite of their faults these heating tubes find abundant employment for they are easily and cheaply made, and can be adapted to fit any shape of vessel.

When the heating tubes are built pretty high so as to obtain a large heating surface, and have all to be covered with juice, the relation of the juice surface to the height of the juice column gets too small, in consequence of which the circulation of the juice is considerably reduced.

### II. Horizontal Tube-Heating Apparatus.

Acting on the knowledge that a rapid steaming can only be accomplished with a large steaming area and a low juice column, Rillieux, Lexa, Jelinek, and others built closed horizontal cylinders or box-shaped vessels with a heating system consisting of a number of narrow tubes of thin section, somewhat inclined to the horizontal and with parallel axes; these passed into a chamber formed beyond the principal partition, from which the steam was led off by different passages. The condensation water was drained off at the bottom of this chamber and the gases liberated at the top, so that this heating system was applicable for juice vapors as well.

In spite of the favorable form of the apparatus, possessing as it did large surfaces and a low juice column, it was subject to many a breakdown. The employment of long narrow tubes entails their being curved round one another, with the result that condensation water lies in the bends and hampers the flow of steam.

This drawback is likewise met with in the upward flow of the steam on its way from the chamber into the pipes since the condensation water is carried along with it and the steam thereby gets cooled.

The comparatively large heating surface of the chamber which is inactive tends also to chill the steam.

Furthermore the tubes suffer from the steam pressure to such an extent that they are often cut through at the stay-plates. A repair during the progress of work is out of question, and afterwards the replacing of a damaged pipe is a heavy job and involves considerable loss of time.

As in the spiral pipes, so here also the circulation of the juice is hindered through the juice column and the friction on the under surfaces of the steam pipes, and when the network of tubes is fairly thick the warm ascending liquid stream does not allow the colder particles to descend, so that the circulation in the lower strata ceases.

A more vigorous circulation can only take place in the topmost portions of the juice and these must be provided with plenty of room for moving in, as is the case in vessels with spiral piping. An insufficient circulation likewise results in incrustations on the upper surfaces of the pipes, and these cannot be removed while work is in progress.

To obtain a greater circulation the so-called circulators were introduced. These were vertical vessels with fixed heating and a stream of juice flowing from beneath. They, however, failed to serve their purpose. As physical laws would show, a colder and specifically heavier liquid does not allow a warmer and specifically lighter one above it when of the same chemical composition, to descend below it; hence no circulation can ensue.

## III. Vertical Heating Apparatus.

Robert employed a vertical heating vessel in the apparatus named after him; it was a vertical cylinder, with a double bottom and corresponding openings; short brass tubes were fitted inside. The space between the heating tubes and the double bottom formed the heating chamber. From the lower bottom two or more pipes led off the condensation water, and from the upper part the gases escaped.

The juices circulated through the pipes, while the latter were surrounded by the steam; the condensation water drained down the outer surface of the pipes and collected at the bottom.

If the drainpipes do not suffice to let off rapidly the condensation water from the furthest parts, the whole heating surface of the lower chamber is covered with this water and is rendered useless.

On boiling the juice, vapors arise and come into contact with the upper partition, whereupon, as in the draining off of the condensation water in the lower chamber, the heating influence of the steam is reduced.

On heating the juices in the pipes the steam-bubbles developed rise vigorously upwards, jolting the liquid along with them; but the latter keeps falling back, to be thrown upwards again and again.

It is self-evident that to surmount a higher juice column a greater heating energy is needed; so that, therefore, in the lowest portions where the greatest transfer of heat should take place, stagnation reigns.

Piedboet introduced a large pipe in the middle of the heating surface with the object of allowing the cooler portions of the liquid to descend to the bottom and thus circulate the juice.

This circulation, however, only occurs in the immediate neighborhood of this large pipe and has practically no influence on the juice in the more distant pipes.

With the further object of encouraging a circulation, little slips of wood were inserted in the middle of the pipes with the object of lessening the juice column and increasing the circulation. As these got loose or easily broken they entirely failed in their object.

These vertical heating apparatuses have the advantage over the horizontal type in that the incrustations are here, not on the outside of the tubes but inside; consequently they are easy of access for cleaning purposes during progress of work without any considerable loss of time, and damaged tubes can be eliminated by simply closing up both ends.

## IV. Other Heating Systems.

It is easily seen that in the above-mentioned heating systems a rational cooking and steaming process has not been attained.

W. Greiner endeavored to prevent the chilling of the steam by his system which consisted of short bent tubes, overlaying one another, with a single entrance for the steam; the condensation water was led off independently from each pipe in one direction.

Marky, Bromovsky, and Schulz followed this plan with a heating apparatus consisting of vertically curved tubes of U-shape, in which the condensation water dripping from all parts to the bottom bend was led off from there by a common pipe. As, however, both these systems cannot be heated with juice vapors, are difficult of access, and therefore are uncontrollable in the event of their getting out of order, they have consequently achieved no appreciable success.

An improved steam heating was thereupon obtained by injecting the juices against the heating tubes whereby the heating surface was artificially increased; this principle has been used in the superposed steam-heating apparatus and with rotating heating systems.

During the last few years the circulation heating chambers of W. Witkowicz have been gradually introduced into the sugar industry. The construction and installation of these in the different juice receptacles give an ideal circulation and steam heating.

The fundamental principle of the construction of this heating chamber consists in the use of pipes crossing each other at a high angle, their ends being directed to the opposite walls of a hermetically sealed vessel, which is sunk in the liquid about to be warmed. The heating steam is introduced into the interior of the chamber, and heats the liquid present in the pipes.

These heating chambers are installed in the liquid in such a way that they rest on a corner of the wrought-iron prism, where a support for leading off the condensation water is likewise fixed. In this way the pipes crossing each other are placed at an angle of 45°. In the upper corner of the prism there is a support for the escape of gases. The support for the injection of steam is in the middle of the front wall. The heating chamber is provided with a vessel for the reception of the condensation water.

The pipes are not made longer than 850 Mm., and these are the ordinary Mannesmann steel pipes, with a metal thickness of 1½ to 2 Mm., and of different diameters for different purposes. So, for example, for warming the diffusion juices the diameter of the pipes is 29 to 40.5 Mm.; for warming the saturated thin and thick syrups, 22 to 32 Mm.; for steam heating apparatus, 20 to 29 Mm.; for syrup boiling and crystallization of by-products, 40 to 50 Mm.; for boiling to grain of first product, 69 to 72 Mm. These circulation heating chambers give the following results of co-efficients of transmission:—

For Diffusion Juice.—In the case of direct steam heating, 12 to 18; of heating with exhaust steam, 10 to 14.

For Scums.—With direct steam, 14 to 20; exhaust steam, 10 to 16.

For Thin and Concentrated Syrups.—With direct steam, 18 to 25; with exhaust steam, 15 to 20.

For boiling down juice, 45 to 70; 1st chamber, 40 to 60; 2nd chamber, 35 to 40; 3rd chamber, 30 to 45; 4th chamber, 28 to 40.

For first product vacuum pan, syrup boiler and crystallizers, 25 to 35.

According to the fall of temperature, the lower, higher, or average figure is reckoned.

The circulation heating chambers can easily be fixed into any receptacle, also in a pipe, indeed, in every place where it is a question of increasing the heating surface in a small space.

The typical installation of the heating chamber necessitates a quick drawing off of the condensation water, reducing its contact with the heating surface and the steam to a minimum. As the rapid drawing off of ammonia is provided for in the upper part of the heating chamber, the heating steam remains in close contact with the whole heating surface.

The setting up of the heating chamber and the typical installations of the network of pipes result in the fact that the warmed liquid cannot stream back, but is thrown out of the pipes in such a way that it flows downward towards the ground, describing a parabolic curve.

Through the uninterrupted movement of the liquid in the pipes, an action is set up in the lower orifices of the pipes, whereby the liquid falling to the ground is taken up again and back on the other side in the same way, so that an uninterrupted circulation is set up in the form of a horizontal 8, which in high temperatures is so pronounced that it may be followed with the eye. Even with the lowest temperatures, the circulation is satisfactory.

In consequence of this, the pipes are hardly ever, if at all, misplaced, and owing to their accessibility, they can easily be cleaned during the process of working.

The advantage of the circulation chambers appears in the higher coefficients of transmission, as compared with the previously described heating systems.

If, for instance, in a horizontal steam heating apparatus, of 240 square metres heating surface, you insert a Witkowicz heating chambers of 24 square metres, this will correspond to the effect of a steam heating apparatus of 320 square metres.

The circulation heating chambers may be used advantageously at different stages of manufacture. As an example of their efficiency, I may say that in the sugar factory at Auschitz, for the warming of the scums after the first saturation, a chamber of 10 square metres heating surface sufficed to warm a quantity of 8,000 metric cwts. with direct steam (162°) from 75° to 95° C. The circulation was so violent that no incrustation took place, and therefore the cleaning of the pipes during the whole of the campaign was unnecessary. By fixing these heating chambers in already existing steam heating and boiling apparata, we can considerably increase their heating surface and thus augment the circulation of the syrups.

So in Auschitz we increased the heating surface of an old vertical first product vacuum pan from 20 sq. metres heating surface, through the fixing up of two Witkowicz heating chambers, to 35 sq. metres. The boiling of the thick syrup to string-proof was carried out with these two chambers, and the boiling lasted only half the time employed formerly. The masse-cuite boiled to 96% dry substance flowed freely out of the pipes of a diameter of 72 mm.

With steam heating and water apparata fitted with heat-chambers, all danger from inactive parts of the chambers are avoided, as well as the costly renewing year by year of the heating pipes.

The steam-heating effect of this apparatus amounts to 100 kilogs. of water per one sq. metre of heating surface for one hour.

From the foregoing observations it will be seen that circulation heating chambers mark an important progress in the method of steam using. The practical heating effect is brought considerably closer to the theoretical, and the result appears in the technical tout-ensemble.—Oesterreich-Ungarische Zeitschrift.

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## *SEEDLING CANES IN TRINIDAD.*

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The experiments with seedling canes have been continued with satisfactory results. From the seedlings raised at St. Clair there is now a selection of canes which class themselves with some of the best raised in other colonies. Through the kindness of Professors Harrison and Watts, I have been able to procure type specimens of a few varieties grown in Demerara and Antigua. Grown in Barbados, the Trinidad canes have proved true to the value shown by the local examination, and in some cases they have shown to even better advantage. It was suggested by a leading planter that trials should be made of canes planted in alternate rows, and in accordance therewith the Arangues "Bourbon" and the "Caledonian Queen" were planted side by side in long rows. It was soon discovered that the "Caledonian Queen" was much the stronger of the two varieties, and the result of the yield, with the analysis, made this still more apparent. "Caledonian Queen" yielded at the rate of 35 tons to the acre while the "Bourbon" only gave 28 tons, the percentage of sucrose of the former being 18.9 and of the latter 15.45. Another "Bourbon" which is of a different character, yielded at the rate of 25.87 tons to the acre, but it was planted adjacent to weaker varieties, which in some measure accounts for its better yield. The yield in sucrose of this variety of "Bourbon" was 17.14. The difference in the sucrose yield of the two "Bourbons" is to be clearly accounted for by their individual characteristics, taken together with the conditions of environment. Close observation led us to doubt the identity of the two "Bourbons," and the matter was discussed in the Departmental

Bulletin for January, 1904, under the heading of "What is the Bourbon Cane?" and I give the following extract, as a record of observations made during the year.

"During the experiments in raising seedling canes at St. Clair we took for a standard a sample of 'Bourbon' plants which were selected and presented to the department by the late Mr. J. S. Wilson of Aranguez estate. For several years the analysis of this cane showed results below that of the regular yield of Bourbon canes of estates in other parts of the island and it was therefore considered questionable whether there was complete identity between the Bourbon as grown on different estates or not.

With a view of testing this point I secured plants of the "Bourbon" grown on one of the Colonial Company's estates through the kindness of P. Abel, Esq., the attorney of the company.

The difference between the appearance of the two canes, and the results of their analysis is equally striking. In the former the color of the cane is essentially distinct, the Colonial Company's cane being a much brighter and cleaner yellow than the Aranguez. The habit, weight per acre, and yield of sugar are also strongly in contrast.

The analytical results are briefly as follows:

SEASON MAY, 1903.

| Bourbon— | Per cent. Sucrose. | Per cent. Glucose. | lbs. per gallon Sucrose. | lbs. per gallon Glucose. | Estimated sugar, tons per acre. | Specific gravity. |
|---|---|---|---|---|---|---|
| Colonial Co.'s cane | 17.14 | 1.25 | 1.849 | .125 | 3.15 | 1078 |
| Aranguez | 15.45 | 1.40 | 1.656 | .140 | .38 | 1072 |
| Caledonian Queen | 18.09 | 0.50 | 1.953 | .050 | 4.11 | 1079 |

In previous years the result of the Aranguez yield was similar, but the estimated yield of sugar for 1903, must not be taken to be an accurate one for this variety as it happens to be based upon the returns of an experimental plot, planted in a particular manner, which allowed one cane to take advantage of another. Caledonian Queen and Bourbon were planted in alternate rows, a suggestion of an experienced planter; the result being that the former overgrew the latter. The result is seen in the fact that while the Caledonian is over average, as to weight per acre, the Bourbon is much under average. The Caledonian Queen practically overgrew and robbed the Bourbon of its nutriment to such a degree that I estimate the area on which the calculations should have been based, should have been increased by one-fortieth and the area upon which the Bourbon was grown decreased by the same amount. Although on the field one-twentieth of an acre of each cane was planted, yet practically the ground occupied by each was Caledonian Queen three-fortieths, Bourbon one-fortieth, an adjustment which will make a considerable difference in the estimate of value of the canes as shown by the analytical returns. The Caledonian Queen gave a yield side by side with the Bourbon, as seen in table.

Now, our experiments appear to show that we have secured in what are known as "Bourbon canes," two distinct varieties. If this is so, a further question may well be asked: Are these canes merely varieties of the one kind, or have they an independent origin?

Personally I am of opinion that there is not only one, but dozens of different kinds of the so-called "Bourbon" canes; which hypothesis would well explain the variable results obtained by different estates.

As a matter of fact, almost any yellow cane, unless it has some specially marked distinctive feature is called a "Bourbon" on the estates; and on our experimental plots, I have frequently heard seedlings called "Bourbon" which I knew to have originated from varieties quite distinct from the Bourbon and therefore not of the same family or blood relationship at all.

Such a mixture of varieties as this, if it exists(?), and I have the opinion of one of the best planters with whom I have discussed the matter, that it does; cannot be good for the industry. This gentleman says: "The extremes of readings for the two Bourbons may be taken to prove what I have always said, that variations in that cane are as great as any observed between it and any other varieties." Now, as the Bourbon has been always taken as a standard in cane experiments, the question arises, what "Bourbon" has been used? Is it the same or different to that used in other colonies. If not, the results of two places working with a different standard would not be easily compared. The question, however, appears to offer a means for simple solution. Let specimens of the so-called "Bourbon" on each estate be sent to a central station and grown in plots side by side. The best kind of "Bourbon" could then easily be selected, and a standard fixed upon which should be common to all experiment stations to their considerable benefit. Again it may be possible, and I consider probable that there may be "Bourbons" which are disease resisting canes, as well as Bourbons that easily succumb to Fungi; and this might easily be proved at the same time.

Further, there may be "Bourbons" that produce fertile seed, as well as some that are infertile, a possibility which would explain the power to raise seedlings in one place and not in another. If one kind could be found of high quality, which could readily be reproduced from seed, it appears clear, that the chances of getting improved canes would be greater, coming from the long acknowledged best of the cane tribe, than from canes whose claim to public favor is not in any way so prominently put forward.

What is the Bourbon cane? We have not answered the question and did not set out to answer it, but write to raise a working hypothesis which may give a solution to a question which, when carefully looked at, appears to be of considerable importance to the sugar interest.

This season it is proposed to eliminate many of the seedlings, which have shown insufficient characters to render them worthy of general cultivation, and to use the area they have previously occupied, for extending the cultivation of selected kinds, so as to afford material for planting on a larger scale.

It would appear from results, that our practice of cutting annually in May for several years past, has led to a diminution of seed production, as most of the varieties have produced either no seed at all, or only small and insignificant quantities. It is proposed therefore, to select and plant a few of each of the best varieties in beds, for seed purposes only, and allow them to remain over without cutting, for longer periods than twelve months. Seed collected in October, 1903, was small in quantity, but a goodly number of plants were raised which will appear in due course. It has also been noted that the seedlings raised during the past four years have not shown the same variety or the same sucrose content as the batches raised six or eight years ago; and the evidence appears to point to this also being due to annual cutting (i. e.) not allowing the cane sufficient period of growth previous to the flowering stage, which generally occurs in Trinidad in October and November of each year.—Prof. J. H. Hart's Annual Report.

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## *BRITISH GUIANA.*

By A. A. Thorne.

The one solitary possession of the British empire in South America is the colony of British Guiana, captured from the Dutch in 1803 and finally ceded to Great Britain by treaty in 1814-15. This colony is one of the five divisions of Guiana, "wild country," which extends on the northern coast of South America from the mouth of the Orinoco to that of the Amazon, and lies between 8 degs. 40 mins. north, 3 degs. 30 mins.

south, and 50 degs. and 68 degs. 30 mins. west; with an estimated area of 690,000 square miles. But little was known of any of the five divisions of Guiana—Venezuelan, British, Dutch, French and Brazilian—prior to 1896, when the seizure by Venezuela of the British outpost at Uruan on the frontier of what was then supposed to be part of British Guiana, resulted in the active mediation of the United States on behalf of Venezuela, and in the declared responsibility of the United States throughout the western hemisphere because of the Monroe doctrine. The Guianas had hitherto been only sugar producing countries with very limited portions of them developed at all, and were just then gaining the attention of capitalists as gold-bearing territories.

The whole coast of British Guiana is flat to an average depth of fifty miles inland, and this physical feature seemed to have determined the Dutch to inhabit and develop only this portion so much resembling Holland. Despite the enormous outlay on canals and sea defences to drain this portion of the colony and keep out the ocean, the Dutch estates along the shore proved exceedingly remunerative; and it is not therefore to be wondered at that the British capitalists—especially when it is known that they were chiefly Scotsmen—considered it their duty to confine the development of the vast colony of 100,000 square miles to some of this small strip of country estimated under two hundred square miles. The cane flourished on these lands, fine sugar factories were established, and Demerara crystals were of such commercial value and repute that even beet sugars were converted into imitations of them and sold as Demerara crystals until the fraud was consistently exposed in Great Britain and severely punished within this decade. The population of the colony (285,000) were all forced to give their sole attention to the sugar cane industry by the Government of the colony, which would not sell Crown lands in smaller plots than of one hundred acres each up to five years ago; which fostered a peculiar system of immigration solely for the benefit of the sugar estates, which further aided the sugar industry by allowing the importation free of duty of all machinery, manures and chemicals for sugar estates; which made up or defrayed the cost of the upkeep of the roads required by these estates; which did not tax the mules and wagons required on sugar estates, while it did severely tax the donkeys and carts of the peasant farmers; which discouraged in every way the opening up of the real country—the *hinterland* as it is called—in every conceivable manner. When the serious competition by beet sugar was felt twenty years ago, political moves were made by the Government and sugar planters to secure the position of Demerara crystals in the British and American markets. The cost of production was reduced in a discreditable manner, that has left painful results. Large estates were amalgamated so as to dispense with much of the skilled labor required. Indentured immigrants were brought from India by the Government in thousands annually to flood the labor market of the estates. The price of unskilled labor in the cane-fields sank to twenty-four cents per day. The owners of the estates curtailed factory expenses, and would not further equip them, but rapidly made what profit was possible in addition to the entire recovery of their capital; then mercilessly "cropped and abandoned" these estates, caring nothing at all for the thousands who were thus thrown out of active employment without the means of finding a livelihood elsewhere in the colony, and still prevented by the laws enacted from being assisted to emigrate to the neighboring countries. The reader will, no doubt, ask if the proprietors were not possessed of common human instincts, and why they did not endeavor to start other industries with the capital they with keen commercial forethought got back from these very sugar estates. He must at once be told that the proprietors of these estates lived in Great Britain, hardly or never visited their sugar estates in British Guiana, knew little or nothing of the conditions of the laborers they employed, took no interest in them or in the colony, except to safe guard their own interests to the detriment of all else. British Guiana bore an unenviable reputation for its yellow fever and only white men of no account in their native lands could be got to go there to dwell. These men would so manage the estates that they eventually became the proprietors of the several estates they controlled, as the absentee proprietors decided to sell; and in very many instances they purchased these estates so cheap that the dismantling of the sugar factories and selling of the machinery and bricks in them alone and at once repaid them the whole price they gave. And the Government yet allowed this ruin of the once great sugar colony because the officials of this Crown colony were of the same type as the managers and overseers of the estates for the very reason already given.—Boston Transcript.

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## *SUGAR IN THE PHILIPPINES.*

By Eber C. Smith, of the Philippine Exposition Board.

The production of sugar in the Philippines is another sad story of neglect and lack of good methods and a proper knowledge of sugar cane and its cultivation, and tariff discrimination against the islands. Even after a good crop has been produced, the crude manner of treating it causes a loss of the juice of thirty per cent., and there is a further loss in boiling the same in open kettles.

It is safe to say that nowhere else in the world are there sugar lands offering advantages equal to those in the Philippine Archipelago, and if Congress would remove the tariff from Philippine sugar, there is little question that they could and would, ere long, supply the United States with the greater portion of the 1,600,000 tons of sugar imported from foreign countries. Neither would the islands need encouragement in the way of bounty to hold their own with the beet in the sugar industry. Apparently this is the rock upon which we, over there are stranded. The beet sugar growers in the United States are opposed to giving us a chance, and so far Congress has listened to them. The beet sugar industry has no natural advantages over cane, and has only outstripped it on account of the physical, chemical and scientific attention, and bounties to foster it in Europe and America.

The sandy, sedimentary, alluvial soil along the seacoast and the rich level lands of the interior grow the most phenomenal crops, and longer withstand the crucial test of time with little or no restoratives. Still many rich valleys in the mountains are well adapted to the growth of sugar cane. The cane so far grown there is confined to the green and yellow varieties, thought to be of Japanese origin. Though rich in sucrose they are generally small, and therefore insufficient in tonnage to make the production what it should be, considering the richness of the soil and the climatic condition. It is also true that there is a steady decrease in size on account of improper cultural methods. Which deterioration is accompanied by an increase of fibre, representing a further loss at the mill. The many useful striped, rose and purple canes which have helped to bring the Hawaiian Islands to the fore, have never been cultivated in the Philippines. The Bureau of Agriculture and Capt. Ahern of the Philippine Bureau of Forestry, are endeavoring to introduce Hawaiian canes there, and good results are confidently expected.

The suggestion made that the public lands be leased for a sufficiently long term and low rate, to induce capital to reclaim the agricultural lands of the islands, would no doubt prove a great incentive to the sugar industry there. The poor people are too poor to reclaim the wild lands, and therefore it will be necessary for some inducement to be held out to capital, and as it is not the policy of the United States to allow capitalists and corporations to purchase large tracts of public lands, the leasing plan might prove to be the proper thing. After the termination of leases, the land could be readily sold upon long terms to the small farmer. Which must be the *object ultimately* to be obtained—that is, to have the masses own their own homes.

It is impossible to state with any degree of accuracy how much land there is in the islands adapted to the growing of sugar cane, or how long it will take to develop the industry to that degree of which the country is capable, but the writer believes it can only be done along the lines pointed out. That the Philippine Islands offer a profitable industry for American energy and capital in the production of sugar there is no doubt. It is to be hoped that the United States Government will remove hampering restrictions at least, if definite encouragement is not given.—Louisiana Planter.

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## *THE BRUSSELS CONVENTION.*

### ITS BENEFICIAL EFFECTS.

R. G. Duncan in Demerara Argosy.

In reviewing the effects of the abolition of the bounties, various considerations present themselves, the more important, of course, being the sugar crops of the world during the past few years, and the comparative prices obtained for sugar from time to time. In 1900, the world's total crop of sugar was 9,600,000 tons, consisting of 3,600,000 tons of cane, and 6,000,000 of beet. In 1901, the crop amounted to 11,000,000 tons, 4,000,000 being cane, and 7,000,000 beet. The sugar crops of 1902 were 9,850,000 tons, 4,150,000 being cane, and 5,700,000 beet. In 1903, crops reached 10,300,000 tons, of which 4,300,000 were cane, and 6,000,000 beet. The average prices realized for 88 per cent. beet sugar, f. o. b. Hamburg were: 1900, 10s. per cwt.; 1901, 8s. 11d.; 1902, 6s. 4d.; 1903, 8s. 5d., and 1904, average to end of July, 8s 9d., today's quotation being 10s. 6d.

The effect of the enormous quantity of sugar made in 1901 is clearly seen in the extremely low range of prices which prevailed in the following year. When the Convention came into force, the visible supplies of ready sugar amounted to 2,300,000 tons, and on 1st January this year supplies available were estimated at about 3,500,000 tons. Today visible supplies are estimated at 2,000,000 tons. In view of the immense stock of sugar on hand when the Convention was ratified, it was natural to expect that its immediate effect on prices would be unimportant. It is only now, after the lapse of a year that the results of the abolition of bounties are being felt. For the ten months, 1st September, 1903, to 30th June, 1904, the increased consumption of sugar on the Continent of Europe, as compared with the previous corresponding period, amounts to, in round figures, 600,000 tons. It is evident that the large surplus stock of sugar which has weighed down the markets of the world for several years is steadily disappearing.

It was anticipated that the Convention would bring about two very marked results, namely, an increase in the consumption on the Continent of Europe, and a reduction in the area devoted to the growth of beet. The first hope has been fully realized, and apparently there has been some curtailment of the acreage under beet culture, although not, perhaps, to the extent expected. It has been stated by competent authorities that an average price of 10s. per cwt. f. o. b. Hamburg is necessary to cover the expenses in connection with the growth and manufacture of beet sugar. A glance at the prices ruling during the past three years shows that it would have been impossible to profitably export beet sugar without the aid of bounties.

### AN UPHILL FIGHT.

As far as British Guiana is concerned, I can safely say that in 1901-02-03 not only have proprietors of estates earned no interest on the capital invested, but, on the whole, serious losses have been sustained, notwithstanding the Imperial grant-in-aid, amounting to about £1 per acre, paid partly in 1902 and partly in 1903. The area under cane has not, however, been reduced, and the total sugar crop of the colony compares favourably with that of past years. On the other hand, the owners of several plantations have not been able to maintain their buildings, machinery and cultivation in good order, owing to the lack of sufficient capital, and these plantations are now undergoing the process of abandonment. Most of the absentee proprietors, with capital at their command, have been able to meet losses, and at the same time maintain and improve the equipment and cultivation of their estates. There is every reason to hope that prices having again reached a paying level, past losses will be recouped, and a fair interest earned on the capital invested. The advance in prices has been more rapid than anyone predicted. It seems that the prevalence of a drought on the Continent, and the prospect of a short crop caused thereby, have had considerable influence in forcing up rates. It can, however, be stated with some degree of certainty, that the future price of beet will not range much, if at all, below 10s. per cwt. The preferential treatment granted by Canada to sugar imported from British colonies, has proved a considerable boon to the West Indies and this colony. The full effects of the treaty for reciprocal trade relations between the United States and Cuba have not yet been felt, but it is evident the United States market will not in the future offer the same advantages as the chief outlet for our sugar that it has done in the past.

### CONFECTIONER'S STRANGE REASONING.

The jam makers and confectioners in the mother country have complained bitterly of the increased cost of sugar, caused, as they assert, by the abolition of bounties. They forget that in 1900 beet averaged 10s. per cwt., and they evidently assume that the rate of 6s. 4d. per cwt. recorded during 1902 represented the true value of sugar, while as a matter of fact, it was far below the natural cost of production, and its continuance meant ruin to the producer who was not assisted by bounties. The sugar duty imposed by Sir Michael Hicks-Beach in 1901, varying from 2s. 11d. to 4s. 2d. per cwt. according to quality, increased the price to the English buyer, who erroneously arrived at the conclusion that the Convention, and not the imposition of sugar duties, occasioned the dearness. Even with the addition of the duty, sugar in England is still much cheaper than it is on the Continent.

### RUM V. CATTLE FOOD.

Of late years the planters here have suffered much loss, owing to the extraordinary decrease in the value of rum. In 1900, the average price per gallon of rum in London was 1s. 9d.; in 1901, 1s. 3d.; in 1902, 11d.; in 1903, 9d.; in 1904, 7½d. In other words, the rum produced per ton sugar is worth $6 less today than it was in 1900. This makes a serious difference when the total value of the crop comes to be reckoned, and it is to be hoped that a big reduction in the output will be followed by a considerable increase in the value of the spirit. The manufacture of cattle food is being taken up in earnest. In this way, a large proportion of the molasses, which now goes to make rum, will be utilized in making cattle food.

### CONFIDENCE RESTORED.

The ratification of the Convention has restored confidence in the sugar industry, and improved its credit. It will undoubtedly be instrumental in preventing the alarming fluctuation of prices, characteristic of past years. With a range of prices equal in value to 10s. per cwt. for 88 per cent. beet, and with an ample and reliable labour supply, the sugar estates of British Guiana should once more become a reasonably safe and sound investment for capital."

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## *SUGAR BEET GROWING EXPERIMENTS IN GREAT BRITAIN AND IRELAND.*

Through the efforts of Mr. Sigmund Stein, of Liverpool, sugar expert, and under his direction, farmers of Great Britain and Ireland have for some years past conducted experiments in the growing of sugar beets, with the view of ultimately developing the sugar business in the United Kingdom to the point of furnishing sufficient supply for home consumption, which hope has been more firmly grounded since the abolition of bounties by the Continental sugar countries, as per the Brussels Convention.

Experiments were conducted in 1903 by fifty-two farmers, thirty-five in England, fifteen in Scotland and two in Ireland, and the results were highly gratifying though due to an unfavorable growing season the average yield per acre was but 14.5 tons of beets, as compared with the average of seventeen tons obtained from experiments made the previous six years. By comparing the analyses of the beets grown under Mr. Stein's direction with those grown in Germany (for the latter taking Mr. F. O. Licht's figures), it is seen that the average weight of beets grown in Great Britain is about 65 per cent. greater than the German grown, and that the quantity of sugar is one hundred parts of juice and coefficient of purity are also higher than shown for the German beet crop of 1903.

From the above, it would seem that, with educated farmers, and a plentiful supply of labor, the sugar industry in Great Britain should soon be put on a commercial basis, and the news that arrangements have been made to secure a large tract of land in Ireland for beet cultivation is a hopeful augury that Mr. Stein's efforts are at last about to bear fruit.—Federal Reporter.

## *DECREASE IN SUGAR CONSUMPTION OF UNITED STATES AND ENGLAND.*

Our readers will be surprised to learn that there has been an actual decrease in the sugar consumption of the United States and England during the end of 1903.

Mr. Sachs, the well-known authority, says that the English sugar consumption was in:

| | 1903. | 1902. |
|---|---|---|
| September | 125,221 | 126,761 |
| October | 106,867 | 104,471 |
| November | 95,249 | 111,190 |
| | 327,337 | 342,422 |

A decrease for three months of 15,000 tons. In fact, during the past three years there has been a notable decrease from January to the end of November. The consumption in 1901 was 1,539,000 tons, while in 1903 it was 1,243,000; this means 300,000 tons less, due possibly to the existing duty. In the United States, where white sugar is consumed, from September 1 to November 30, 1903, the sugar consumption was 396,287 tons, while in 1902, during the same period, it was 467,509 tons, or a decrease for three months of 71,000 tons. The estimated world's production for 1903-1904 is about 700,000 tons greater than that of 1902-1903, and as the total sugar on hand continues to be very high, it is recommended that the sugar manufacturers of Continental Europe, for their own protection, decrease for the coming campaign the contracted area in beets as compared with previous years.—The Sugar Beet.